

PATENT APPLICATION
TECHNIQUES FOR RECEIVING INFORMATION DURING
MULTIMEDIA PRESENTATIONS AND COMMUNICATING THE
INFORMATION

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**TECHNIQUES FOR RECEIVING INFORMATION DURING
MULTIMEDIA PRESENTATIONS AND COMMUNICATING THE
INFORMATION**

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CROSS-REFERENCES TO RELATED APPLICATIONS

The present application claims priority from the following applications, the entire disclosures of which are herein incorporated by reference for all purposes:

(1) U.S. Provisional Patent Application No. 60/244,771, filed October 31, 2000 entitled "TECHNIQUES FOR CAPTURING AND COMMUNICATING INFORMATION DURING A MULTIMEDIA PRESENTATION";

(2) U.S. Non-Provisional Patent Application No. 09/521,252, filed March 8, 2000 entitled "METHOD AND SYSTEM FOR INFORMATION MANAGEMENT TO FACILITATE THE EXCHANGE OF IDEAS DURING A COLLABORATIVE EFFORT"; and

(3) U.S. Non-Provisional Patent Application No. __/__, (Attorney Docket No. 15358-006110US) entitled "A NETWORKED PERIPHERAL FOR VISITOR GREETING, IDENTIFICATION, BIOGRAPHICAL LOOKUP AND TRACKING" filed November 15, 2000, which in turn claims priority from U.S. Provisional Patent Application No. 60/166,081, entitled "VISITOR KIOSK: A NETWORKED PERIPHERAL FOR VISITOR GREETING, IDENTIFICATION, BIOGRAPHICAL LOOKUP, AND TRACKING" filed November 17, 1999, the entire disclosure of which is herein incorporated by reference for all purposes.

The present application incorporates by reference the entire disclosure of the following application for all purposes:

(1) U.S. Non-Provisional Patent Application No. __/__, (Attorney Docket No. 15358-006210US) entitled "TECHNIQUES FOR CAPTURING INFORMATION DURING MULTIMEDIA PRESENTATIONS" filed concurrently with this application.

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BACKGROUND OF THE INVENTION

The present invention is related to reception and communication of multimedia information, and more particularly to techniques for receiving information during multimedia presentations and for communicating the received information to one or more access devices.

Multimedia presentations combining audio and video information are commonly used for communicating information in various environments such as commercial environments, academic environments, and others. For example, in a commercial environment, multimedia presentations may be used during meetings, during marketing presentations, etc. In academic environments multimedia presentations may be used for presenting information during lectures, class project presentations, etc. Conventionally, multimedia presentations are generally prepared using applications, such as Microsoft PowerPoint, which store the multimedia presentation in an accessible format, e.g. a multimedia presentation file. The multimedia presentation file is typically stored on a device such as a laptop computer which can be carried to the presentation environment. The multimedia information contained in the multimedia presentation file (referred to as "multimedia presentation information") may then be presented by connecting the laptop computer to an output device and by "executing" or "opening" the multimedia file. "Executing" or "opening" the multimedia presentation generally causes information stored in the file, such as audio and video information, to be output via the output device.

The increasing popularity of multimedia presentations has also given rise to a need for recording the information presented during multimedia presentations to allow persons unable to attend the live presentation to be able to view the presentation at a later time. The recording also provides an archive which allows interested parties to review the presentation at a later time. Conventionally, archiving of presentations is typically done by storing a digital version of the multimedia presentation file. For example, for presentations prepared using Microsoft PowerPoint, the "*.ppt" may be stored. A disadvantage of this technique is that anyone reviewing the presentation at a

later time is typically required to use the same version of the application which was used to create the stored multimedia presentation. This may be difficult to satisfy at all times, especially when the presentation was prepared a long time ago and the application used to prepare the multimedia presentation is no longer available. Further, presentations

5 prepared using applications running on a particular operating system, for e.g. Microsoft Windows, may not be reviewable by users using a UNIX based system. Additionally, due to their audio and video content, multimedia presentation files are typically very large, may contain many attachments, and thus consume valuable system and memory resources. Also, multimedia presentation files fail to capture audio information such as
10 comments made by the presenter during the presentation and/or comments or questions asked by the attendees during the live presentation.

Another commonly used technique for recording multimedia presentations is to use a video camcorder. However, this technique also has several disadvantages. For example, a person is required to operate the video camcorder. Also, due to the location of
15 the video camcorder with respect to the presentation, the video recording may not be of good resolution and clarity. Further, since the video camcorder equipment has to be placed right in front of the presentation to record the presentation, valuable space, which could have been occupied by the attendees, is now wasted by the video camcorder equipment. The line of sight of the video camcorder may also be inadvertently obstructed
20 by attendees of the presentation. Also, since the information is stored on a video cassette, a user needs to have access to a video player to view information stored on the video cassette.

In light of the above, there is a need for a system which can receive information during multimedia presentations without the disadvantages associated with
25 conventional recording techniques. It is desirable that the system be able to communicate the received information to devices and other consumers of the information.

SUMMARY OF THE INVENTION

The present invention discloses techniques for receiving information
30 during multimedia presentations and for communicating the received information to one or more information access devices. According to an embodiment of the present invention, a presentation recorder adapter is provided for communicating information received during a multimedia presentation to information access devices. The adapter may be coupled to a first source and configured to receive multimedia presentation

information, comprising video information and audio information, from the first source. The adapter may also be configured to receive information from a second source separate from the first source during the multimedia presentation. For example, the second source may be an attendee of the multimedia presentation. The adapter may be configured to
5 transmit the multimedia presentation information received from the first source and the information received from the second source to one or more information access devices.

According to an embodiment of the present invention, the adapter may be configured to process the multimedia presentation information received from the first source and the information received from the second source to generate a first
10 representation of the multimedia presentation information and the information received from the second source. The adapter may then be configured to transmit at least a portion of the first representation to the device.

According to another embodiment of the present invention, the adapter may be configured to receive a request from the device requesting transmission of a first
15 portion of the first representation of the multimedia presentation information and the information received from the second source. In response to the request, the adapter may be configured to determine the first portion of the first representation requested by the device, and to transmit the first portion of the first representation to the device.

According to another embodiment of the present invention, the adapter
20 may be configured to select a plurality of video frames from the video information received by the adapter, to synchronize the plurality of video frames with the audio information included in the multimedia presentation information received from the first source and audio information included in the information received from the second source, and to store information related to the plurality of video frames.

According to an embodiment of the present invention, a system is provided
25 for communicating information received during a multimedia presentation to a device. The system may comprise a first module configured to receive multimedia presentation information from a first source, the multimedia presentation information comprising video information and audio information, a second module configured to receive
30 information from a second source separate from the first source during the multimedia presentation, a processor, a memory coupled to the processor, the memory configured to store a plurality of code modules for execution by the processor, and a transmitter configured to communicate information received by the system from the first source and the second source to the device.

According to yet another embodiment, the present invention provides a computer program product stored on a computer readable medium for communicating information received during a multimedia presentation. The computer program product may comprise code for receiving multimedia presentation information from a first source, the multimedia presentation information comprising video information and audio information, code for receiving information from a second source separate from the first source during the multimedia presentation, and code for communicating the multimedia presentation information received from the first source and the information received from the second source to one or more access devices.

The foregoing, together with other features, embodiments, and advantages of the present invention, will become more apparent when referring to the following specification, claims, and accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Figs. 1A, 1B, 1C, and 1D depict various environments which may incorporate an embodiment of the present invention;

Fig. 2 is a simplified block diagram of a computer system suitable for use as a presentation recorder appliance according to an embodiment of the present invention;

Fig. 3 is a simplified flowchart depicting processing performed by a presentation recorder appliance for capturing/recording information during a multimedia presentation according to an embodiment of the present invention;

Fig. 4 is a simplified flowchart showing processing performed by a presentation recorder appliance for selecting keyframes according to an embodiment of the present invention;

Fig. 5 depicts an example of a SMIL file according to an embodiment of the present invention;

Fig. 6 depicts an example of a RealPix file for describing video keyframe tracks according to an embodiment of the present invention;

Fig. 7 depicts an example of an entry in an augmented inverted index according to an embodiment of the present invention;

Fig. 8 depicts various modules for recording information during multimedia presentations according to an embodiment of the present invention;

Figs. 9A and 9B depict a user interface for retrieving the recorded multimedia information according to an embodiment of the present invention;

Figs. 10A and 10B depict examples of configurations in which a presentation recorder adapter according to an embodiment of the present invention may be used; and

Figs. 11A, 11B and 11C depict various embodiments of a presentation recorder adapter.

DESCRIPTION OF THE SPECIFIC EMBODIMENTS

The present invention provides techniques for capturing information during multimedia presentations. The captured information may include information, such as audio and/or video information, stored in a multimedia presentation file and output via an output device. The term “multimedia presentation information” will be used to refer to information stored in a format, such as a multimedia presentation file (or other format), and output using one or more output devices. According to teachings of the present invention, the captured information may also include information from sources other than the multimedia presentation file (collectively referred to as “external sources”). For example, the captured information may include audio information from attendees of the multimedia presentation or the audio narration of the presenter of the multimedia presentation. According to an embodiment of the present invention, the captured information, including multimedia presentation information and information from external sources, is processed and stored in a format which facilitates efficient storage and retrieval.

Figs. 1A, 1B, 1C, and 1D depict various environments which may incorporate an embodiment of the present invention. The embodiments of the present invention depicted in Figs. 1A, 1B, 1C, and 1D are merely illustrative of the various configurations in which the present invention may be embodied and do not limit the scope of the invention as recited in the claims. One of ordinary skill in the art would recognize other variations, modifications, combinations, and alternatives.

Fig. 1A depicts a presentation recorder appliance (PRA) 100 coupled to a multimedia presentation source (MPS) 102 via communication link 108 and to a presentation output device 104 via communication link 110. PRA 100 may also be coupled to communication network 112, data storage 114, and other devices or networks. MPS 102 is generally a device which is capable of storing or providing access to multimedia presentation information stored in a particular format. For example, MPS 102

may be a laptop or a data processing device which stores the multimedia presentation information in the form of a multimedia presentation file, e.g. a PowerPoint “*.ppt” file.

MPS 102 may also be a network which stores the multimedia presentation information or a device which provides access to the multimedia presentation information via the network. For example, MPS 102 may be coupled to a networked system and be capable of accessing the multimedia presentation information via a communication link. The multimedia presentation information may include audio information, video information, other information, and/or combinations thereof.

Output device 104 provides a means for outputting or presenting the multimedia presentation information stored by or accessed by MPS 102. As shown in Fig. 1A, output device 104 may comprise a video output device 104-a and an audio output device 104-b. Video output device 104-a may be configured to output video and graphics information included in the multimedia presentation information. Examples of video output device 104-a include a screen, a monitor, a television, and other like devices. Audio output device 104-b may be configured to output audio information included in the multimedia presentation information. Examples of audio output device 104-b include one or more speakers, and other like devices. It should be apparent that various configurations of output device 104, having more or less components than those depicted in Fig. 1A, may be used in conjunction with the present invention. According to an embodiment of the present invention, output device 104 and MPS 102 may be embodied in a single device. For example, a laptop computer may be configured to store the multimedia presentation file and to output the multimedia presentation information when the file is “executed” or “opened.”

According to the teachings of the present invention, PRA 100 may be configured to capture/record information presented during a multimedia presentation. The information captured or recorded by PRA 100 may include the multimedia presentation information stored or accessed by MPS 102 and information received from external sources during the presentation. In the embodiment depicted in Fig. 1A, PRA 100 is coupled to MPS 102 via communication link 108 and coupled to presentation output device 104 via communication link 110. PRA 100 may receive the multimedia presentation information from MPS 102 via communication link 108, store a copy of the multimedia presentation information before forwarding the multimedia presentation information to output device 104 via communication link 110. Communication links 108 and 110 depicted in Fig. 1A may be hardwire links, optical links, satellite or other

wireless communications links, wave propagation links, or any other mechanisms for communication of information.

According to the teachings of the present invention, PRA 100 may also be configured to capture information from external sources 106 during the multimedia presentation. As stated above, external sources 106 may include the presenter, attendees of the presentation, and other sources. Examples of information received from external sources 106 include audio information from attendees of the presentation, audio narration of the person presenting the multimedia presentation, video information, and the like.

According to an embodiment of the present invention, PRA 100 processes the multimedia presentation information received from MPS 102 and information received from external sources 106 and stores it in a format suitable for subsequent storage and retrieval. The stored format thus stores a representation of the information received from MPS 102 and from external sources 106. The processing performed by PRA 100 may include digitizing the audio and video information streams contained in the captured information, selecting keyframes from the video stream for storage, synchronizing the video information with the audio information, storing the synchronized video and audio information in a format suitable for later retrieval, applying speech recognition techniques to the audio sources, applying optical character recognition techniques to the video information, indexing the stored information to facilitate storage and retrieval, and several other functions. Details related to the functions performed by PRA 100 are described below. PRA 100 may itself be comprised of several components and modules which perform the functions.

The information received and processed by PRA 100 may be stored on PRA 100 itself, or may be alternatively be stored on a data storage device 114 coupled to PRA 100 from where it can be accessed by a user for subsequent retrieval. The recorded information may be stored in a plurality of formats which can be accessed by the user using a variety of different interfaces. For example, the captured information may be accessed via a telephony interface, via a network interface, via a serial interface, and via other interfaces.

In a networked environment, the information received and processed by PRA 100 may be stored on one or more data storage devices coupled to communication network 112 from where the recorded information can be retrieved via a plurality of different interfaces. Communication network 112 may itself be comprised of many interconnected computer systems and communication links. While in one embodiment,

communication network 112 is the Internet, in other embodiments, communication network 112 may be any suitable computer network.

Fig. 1B depicts another embodiment of the present invention for capturing information during multimedia presentations. In the embodiment depicted in Fig. 1B, PRA 100 receives audio information included in the multimedia presentation information from MPS 102 via communication link 118, and receives video information included in the multimedia presentation information via communication link 116. According to a specific embodiment of the present invention, the video information may be communicated as a National Television System Committee ("NTSC") or a video graphics adapter ("VGA") compliant signal. However, other types of video and audio signals may also be used in conjunction with the present invention.

PRA 100 makes a copy of the audio and video information before forwarding the audio and video information to output device 104 via communication links 122 and 120, respectively. It should be apparent that in alternative embodiments of the present invention, various types of communication links may be used to communicate multimedia presentation information from MPS 102 to PRA 100 and from PRA 100 to output device 104. Communication links 116, 118, 120, and 122 depicted in Fig. 1B may be hardwire links, optical links, satellite or other wireless communications links, wave propagation links, or any other mechanisms for communication of information. Similar to the embodiment depicted in Fig. 1A, PRA 100 depicted in Fig. 1B may also receive information from external sources 106.

Fig. 1C depicts yet another embodiment of the present invention for capturing information during multimedia presentations. According to the embodiment depicted in Fig. 1C, PRA 100 receives the multimedia presentation information from MPS 102 via communication link 124, and output device 104 receives the multimedia information directly from MPS 102 via communication link 126. This type of configuration is generally used where communication links 124 and 126 are wireless communication links. However, communication links 124 and 126 may also be hardwire links, optical links, satellite links, wave propagation links, or any other mechanisms for communication of information. Similar to the embodiments depicted in Fig. 1A and Fig. 1B, PRA 100 depicted in Fig. 1C may also receive information from external sources 106.

Fig. 1D depicts yet another embodiment of the present invention for capturing information during multimedia presentations. In the embodiment depicted in

Fig. 1D, output device 104 receives audio and video information included in the multimedia presentation information directly from MPS 102 via communication links 130 and 128, respectively. Output device 104 may then process the information and then the processed audio and video information to PRA 100 via communication links 134 and 132.

5 PRA 100 may also be configured to receive/capture information from external sources 106. In the configuration depicted in Fig. 1D, output device 104 may convert the various audio and video formats output by MPS 102 to a suitable standard format which is then forwarded to PRA 100. For example, output device 104 may convert a VGA signal format received from MPS 102 to a standard NTSC signal format and then communicate
10 the NTSC signal to PRA 100. Since PRA 100 receives a standardized format, the design of PRA 100 is simplified since it no longer has to support the plurality of formats which may be output by MPS 102.

Fig. 2 is a simplified block diagram of a computer system 200 suitable for use as a PRA 100 according to an embodiment of the present invention. Computer
15 system 200 may include at least one processor 204 which communicates with a number of peripheral devices via bus subsystem 202. These peripheral devices may include a storage subsystem 216, comprising a memory subsystem 218 and a file storage subsystem 220, user interface input devices 208, user interface output devices 210, video processing subsystem 214, audio processing subsystem 212, and a network interface subsystem 206.
20 The input and output devices allow user interaction with computer system 200. Network interface subsystem 206 provides an interface to outside networks, including an interface to communication network 112, and may be coupled via communication network 112 to corresponding interface devices in other computer systems, for example other PRAs. As previously stated, communication network 112 may itself be comprised of many
25 interconnected computer systems and communication links. These communication links may be hardwire links, optical links, satellite or other wireless communications links, wave propagation links, or any other mechanisms for communication of information. While in one embodiment, communication network 112 is the Internet, in other embodiments, communication network 112 may be any suitable computer network.

30 User interface input devices 208 may include a keyboard, pointing devices such as a mouse, trackball, touchpad, or graphics tablet, a scanner, a touchscreen incorporated into the display, audio input devices such as voice recognition systems, microphones, and other types of input devices. In general, use of the term "input device" is intended to include all possible types of devices and ways to input information into

computer system 200. These devices may be used to control the operation of computer system 200.

User interface output devices 210 may include a display subsystem, a printer, a fax machine, or non-visual displays such as audio output devices. The display subsystem may be a cathode ray tube (CRT), a flat-panel device such as a liquid crystal display (LCD), or a projection device. The display subsystem may also provide non-visual display such as via audio output devices. In general, use of the term “output device” is intended to include all possible types of devices and ways to output information from computer system 200. These output devices may be used to receive status information and other feedback information from computer system 200.

Storage subsystem 216 stores the basic programming and data constructs that provide the functionality of the present invention. For example, the various modules for processing and recording multimedia information may be stored in storage subsystem 216. The multimedia information captured and processed by PRA 100 may also be stored in storage subsystem 216. These software modules are generally executed by processor 204.

Memory subsystem 218 may include a number of memories including a main random access memory (RAM) 224 for storage of instructions and data during program execution and a read only memory (ROM) 222 in which fixed instructions may be stored. File storage subsystem 220 provides persistent (non-volatile) storage for program and data files, and may include a hard disk drive, a floppy disk drive along with associated removable media, a Compact Digital Read Only Memory (CD-ROM) drive, an optical drive, or removable media cartridges. The databases and modules implementing the functionality of the present invention may be stored by file storage subsystem 220.

Audio processing subsystem 212 is responsible for capturing audio information received by computer system 200, and processing the audio information to facilitate storage of the captured audio information. Video processing subsystem 214 may be configured to capture video information, and to process and store the video information for subsequent retrieval.

Bus subsystem 202 provides a mechanism for letting the various components and subsystems of computer system 200 communicate with each other as intended. Although bus subsystem 202 is shown schematically as a single bus, alternative embodiments of the bus subsystem may utilize multiple busses.

Computer system 200 itself can be of varying types. Due to the ever-changing nature of computers, the description of computer system 200 depicted in Fig. 2 is intended only as a specific example for purposes of illustrating the preferred embodiment of the present invention. It should be apparent that many other configurations of PRA 100 are possible having more or less components than computer system 200 depicted in Fig. 2.

Fig. 3 depicts a simplified flowchart 300 showing processing performed by PRA 100 for capturing/recording information during a multimedia presentation according to an embodiment of the present invention. As shown in Fig. 3, the process of capturing information during a multimedia presentation may be initiated when PRA 100 receives a signal to commence the recording (step 302). The signal may be communicated to PRA 100 using an input device of PRA 100, or alternatively may be communicated to PRA 100 via a remote device. In one embodiment of the present invention, PRA 100 may receive the signal to start the recording directly from MPS 102. For example, when a multimedia presentation file is "executed" or "opened" a signal may be automatically sent to PRA 100 from MPS 102 instructing PRA 100 to initiate the recording process. In a networked environment, the signal may also be received by PRA 100 via a network interface.

PRA 100 may then receive the multimedia presentation information, including video and/or audio information, from MPS 102 (steps 304 and 308), and receive information from the external sources (step 306). Steps 304, 308, and 306 may be performed in parallel. It should be apparent that step 304 is performed only if the multimedia presentation information includes video information, and likewise step 308 is performed only if the multimedia presentation information includes audio information. The information received from external sources may include, for example, audio information from the presenter of the information, audio information from the attendees of the presentation, for example questions or comments from the audience, audio and/or video information from other sources present during the presentation.

Steps 304, 308, and 306 may be performed during the duration of the multimedia presentation, or until PRA 100 receives a signal to stop the recording process. As with the signal to initiate the recording process, a signal to stop the recording process may be communicated to PRA 100 using an input device of PRA 100, or alternatively may be communicated to PRA 100 via a remote device. According to a specific embodiment of the present invention, PRA 100 may receive the signal to stop the

recording directly from MPS 102, for example, after "execution" of the multimedia presentation file has completed or has been halted. In a networked environment, the signal may also be received by PRA 100 via a network interface. According to an embodiment of the present invention, the step of receiving information from external source may be performed even after steps 304 and 308 have been stopped. This allows the present invention to capture discussions etc. which may occur after execution of the multimedia presentation file has been completed or halted.

The information received by PRA 100 during steps 304, 308, and 306 may then be processed to enable storage and subsequent retrieval of the information.

According to step 310, the video information received by PRA 100 is converted to a digital format or digitized (step 310). The audio information received by PRA 100 may also be digitized (step 312). Steps 310 and 312 may be performed only if the video and audio signals received by PRA 100 are in analog format. Steps 310 and 312 may not be performed if the video and audio signals received by PRA 100 are already in digital format.

PRA 100 may then select keyframes from the digitized video information for storage and discard the other frames (step 314). The selected frames are generally representative of a contiguous subset of video information. According to an embodiment of the present invention, PRA 100 only stores information related to the keyframes and discards other video information. In this manner, the amount of storage resources required for storage of the captured video information is reduced. In alternative embodiments of the present invention, for example, where storage resources are available in abundance, PRA 100 may also be configured to store information related to the keyframes as well as the other video information.

As indicated above, storing only the keyframes information reduces the storage resources required for storing the video information. For example, a typical video stream or sequence is composed of a large number of frames, typically 60 frames per second, and each frame may contain 640x480 pixels. Assuming each pixel is represented by a byte, 307,200 bytes would be required to store each 640x480 frame. A 1-hour video containing 216,00 frames would thus require a massive 66GB of storage space to store the video information in an uncompressed format. Additionally, sequentially scanning through such a huge amount of stored video information to locate desired content is inconvenient and time consuming. By selecting a limited number of keyframes that are representative of a contiguous subset of video information, the present invention reduces

the amount of required storage space. Further, the frames chosen during step 314 provide a convenient means for browsing the content of the captured video and indicate points in the video sequence where replay could be started.

Fig. 4 depicts a simplified flowchart 400 showing processing performed by PRA 100 for selecting and storing keyframes according to an embodiment of the present invention. As previously stated, a video sequence or stream comprises one or more video frames. According to flowchart 400 depicted in Fig. 4, PRA 100 compares sequential frames in the video sequence and selects and stores only those frames (“keyframes”) that are significantly different from the previously selected frames. The keyframe selection process is initiated when the first frame from the captured video stream is selected and stored as a keyframe (step 402). The first frame is then identified or tagged as the “last stored frame” (step 404). For example, a variable “last_stored_frame” may be initialized to point to the first frame.

PRA 100 then determines if there are more frames existing in the video sequence (step 406). If there are no more frames, thereby indicating that all the frames in the captured video sequence have been processed, keyframe selection processing is terminated (step 408). If it is determined in step 406 that more frames exist, PRA 100 then accesses the next frame in the video sequence (step 410).

PRA 100 then compares the frame selected in step 410 with the frame identified or tagged as the “last stored frame” (or the frame pointed to by the “last_stored_frame” variable) (step 412). The comparison may involve determining the differences between the frames. Upon comparison, if the difference between the frame selected in step 410 and the “last stored frame” exceeds a user-configurable threshold, the frame selected in step 410 is selected and stored as a keyframe (step 414). The frame selected and stored in step 410 is then designated as the “last stored frame” (the “last_stored_frame” variable is updated to point to the frame stored in step 410). Processing then continues with step 412. If however, the difference between the frames does not exceed the threshold value, then processing continues with step 406.

The comparison performed in step 412 is an important determiner of system performance. If the comparison results in too many frames being selected, a large amount of storage space will be used for storage of the video information and browsing the keyframes will be inefficient (almost like re-playing the entire video stream). On the other hand, if the comparison results in too few keyframes being selected and stored, even though a large storage reduction is achieved, important information in the content of the

video stream may be missed. The comparison threshold value should be properly configured to obtain optimal comparison such that an appropriate number of keyframes are selected as keyframes.

According to an embodiment of the present invention, several different methods may be used for comparing frames. These include image-based comparison methods, text-based comparison methods, comparison methods based on external stimulus, comparison methods based on environmental measurements, time-based sampling methods, combinations of the aforementioned methods, and others.

According to an embodiment of the present invention using an image-based comparison method, PRA 100 uses characteristics of the image pixels of the two frames being compared to decide whether the frames are different. According to one technique, PRA 100 calculates the sum of the differences between corresponding pixels in the two frames being compared. If this value exceeds a use-configurable preset threshold value, the frames are identified to be different from one another, and the frame accessed in step 410 is stored as a keyframe. The differences may be raised to the Nth power before being added to an accumulator. Another embodiment may apply an image processing operator to the two frames before calculating the sum of the differences. An example of such an operator is an edge detector (e.g. the Sobel detector described in R.O. Duda and P.E. Hart, Pattern Classification and Scene Analysis, J. Wiley, New York, 1973, the contents of which are herein incorporated by reference in their entirety for all purposes).

According to another embodiment of the present invention, PRA 100 may use optical character recognition (OCR) text-based methods to compare the frames in step 412 of flowchart 400. Using this technique, PRA 100 can detect changes in words between two frames which might be very difficult to detect using only image-based comparison methods. For example, PRA 100 may detect a word “true” being changed to “false” in the frames being compared. Using a text-based comparison method, PRA 100 may decide that the two frames are different if they contain more than a fixed number of characters that are different. According to a specific embodiment of the present invention, in order to provide tolerance to OCR errors, the threshold may require that the characters that are different from each other in the two frames be contiguous.

According to another embodiment of the present invention, PRA 100 may be configured to select and store a frame upon receiving stimulus or signal from MPS 102 or some other signal source. According to an embodiment of the present invention, a

serial connection may be provided between MPS 102 and PRA 100. This connection may be used to carry information from MPS 102 (e.g. from a keyboard or mouse coupled to MPS 102, from a software application running on MPS 102, etc.) to PRA 100 indicating when a new slide or frame is displayed. For example, every time a user touches the keyboard, moves or clicks a mouse, or explicitly causes the software application that is displaying the multimedia presentation to advance to the next frame, the next frame may be saved as keyframe. According to another embodiment of the present invention, this method of keyframe selection may be coupled to a video buffer that continuously retains "N" seconds of video. When an external stimulus is received by PRA 100, more than one keyframe may be chosen from the buffer—e.g., "M" seconds before the stimulus and "M" seconds after the stimulus.

According to another embodiment of the present invention, keyframe selection may also be done based on signals received from sensors attached to MPS 102, PRA 100, output device 104, or to other devices. For example, sensors such as video cameras mounted on output device 104 or MPS 102 may detect when the person making the presentation gestures towards the device. Even though the person may not actually touch the device, such a motion may indicate that the person is drawing attention to the material output via output device 104. Accordingly, PRA 100 may be configured to select and store a frame when such a gesture is made upon receiving a signal in response to the gesture from the device, e.g. a video camera. According to another technique, PRA 100 may receive an environmental measurement from a device such as a microphone mounted on MPS 102, PRA 100, output device 104, or elsewhere. When the speaker's volume increases, this may indicate that the speaker is facing towards the microphone while speaking, and video frames during this period may be selected as keyframes and stored.

According to another embodiment of the present invention, as an adjunct to the above described methods, PRA 100 may be configured to select and store keyframes at a fixed sampling interval (e.g. every 2 minutes) during times when the other methods do not choose any frames. This may help provide a level of error tolerance in that if the other methods fail to detect a significant difference, the time-based sampling will at least capture some data.

Several combinations of the above-described comparison methods may be used by PRA 100 in alternative embodiments of the present invention. According to an embodiment of the present invention, PRA 100 may apply all the above mentioned

methods in parallel and store all the frames output by the methods as keyframes.

According to another embodiment of the present invention, PRA 100 may be configured to apply all the above mentioned methods in parallel and store a frame only when “M” out of “N” methods select the frame as a keyframe.

5 Referring back to Fig. 3, PRA 100 may synchronize the captured video information (or the selected video keyframes) and the digitized audio information (step 316). The video keyframes and audio tracks are synchronized so that when the recorded multimedia information is played back, the keyframes and audio tracks will be played in sync as they originally occurred. According to an embodiment of the present invention,
10 synchronization may be accomplished by recording a timestamp when each keyframe is captured and stored and at the beginning of each sound track. The timestamp may encode the current date and time, perhaps to fractions of seconds.

For synchronization purposes, clock initialization is generally not an issue when the video and audio data are captured by using the same processor as that
15 processor’s clock may be used for the timestamp, e.g. when PRA 100 uses a single processor to capture the information. However, if the video information and any of the audio tracks are captured using different processors, then special synchronization procedures have to be performed if the clocks of the various processors are not set to the same time. These special synchronization procedures may include designating one of the
20 processors (typically, the processor that performs video capture) as the “master.” At startup time the difference in time between the master’s clock and the non-master clocks is recorded. The difference value is then used by the non-master systems to calculate and output master-adjusted timestamps. Alternatively, the non-master systems may query the master for its clock value before generating a timestamp. While this method may
25 increase the communication costs, it compensates for differences in clocks that become more evident over time.

Synchronizing or cross-referencing the selected video frames with the audio information allows a user to retrieve sections of the multimedia presentation and hear the audio associated with the sections. For example, when a software application is
30 used to playback the information recorded and stored by PRA 100, the software application may monitor the timestamps associated with the video and audio information to output the information at appropriate times.

Synchronization also allows a user to randomly access the stored information. For example, a control such as a slider control which can be dragged along a

time line may be provided by a software application used to retrieve the stored information. The software application may map the position of the slider to a discrete time between the beginning and end of the multimedia presentation. The keyframe displayed at that discrete time may be displayed. The audio track may also be advanced or rewound to the same time and output to the user. According to an embodiment of the present invention, the audio streams may be broken down into subsequences or "chunks" where each chunk starts and ends when a keyframe is captured. A user may be allowed to select where to begin replay of the presentation by selecting a keyframe and the audio corresponding to that keyframe may be output.

According to an embodiment of the present invention, the synchronization data for information captured during a multimedia presentation, including the timestamps for the audio and keyframe tracks, may be stored/represented in several ways. According to a specific embodiment of the present invention, a Synchronized Multimedia Interface Language (SMIL) format file may be used to name the audio and video tracks. Fig. 5 depicts an example of a SMIL file for a multimedia presentation that includes one audio track and five keyframes. A RealPix file, shown in Fig. 6, may be used to describe the video keyframe track. The file contains the names of the individual JPEG images and the times during the replay when they should be displayed.

Referring back to Fig. 3, PRA 100 may then store the audio and video information in a format which facilitates retrieval (step 320). The multimedia information may be stored in a plurality of formats which may be retrieved by a user using a plurality of different interfaces. For example, the multimedia information may be stored as an HTML document which may be accessed by a user via a network interface using a web browser. Other formats in which the presentation may be stored include Synchronized Multimedia Interface Language (SMIL) format, HTML+Time format, Flash format, Quicktime format, text format, and other formats which can be used to represent recorded presentations, and the like.

Alternatively, the audio and video information may be subjected to further processing (step 318). For example, the video information may be processed to extract textual information and image information from the video information. According to an embodiment of the present invention, optical character recognition (OCR) techniques may be applied to extract textual and other content information from the video information. The extracted information may be indexed and annotated to the video information to facilitate full text retrieval and keyword search capabilities for the video

information. Indexing and cross-referencing of the textual information with the video information allows a user to retrieve sections of the video information based on textual information.

Audio information may also be processed in a manner similar to the video information. For example, voice recognition techniques may be applied to the audio information to recognize sources of the audio information, e.g. identify the speakers of the audio information, and to extract textual information from the audio information. According to an embodiment of the present invention, transcripts may be generated corresponding to the audio information. Results from the voice recognition analysis may be annotated and cross-indexed with the audio information. This allows retrieval of segments of the audio information and their related textual information. Extraction of text information from the audio information also facilitates full text indexing and keyword searching capabilities on the audio information.

The results obtained from applying OCR techniques to the video keyframes and applying speech recognition techniques to the audio information may be indexed for full text retrieval. Such indexing allows a user to access video or audio information using keyword search techniques. For example, a user may provide a keyword to an application used for retrieving the multimedia information, and the application may output video and audio information containing the keyword.

According to an embodiment of the present invention, an “inverted index” may be used for indexing purposes. An inverted index contains a list of words that occur in the various multimedia presentations captured by PRA 100, the filenames (which may be used for storing the information captured) in which the words occur, and the position within the files where the words occur. The inverted index may be augmented with information indicating the media type for each indexed word. This information allows a software application used for retrieving the information to treat the different media types differently.

Fig. 7 shows an example of an entry in an augmented inverted index. The media type 702 may be a document, a keyframe, audio, video, and the like. If media type 702 is a document, “position” 704 may refer to the specific byte in the document file. If media type 702 is keyframe, position 704 may refer to the number of the keyframe. If media type 702 is audio or video, position 704 may refer to a position in time in the stream.

The multimedia information stored by PRA 100 may be subsequently accessed by a user via a plurality of interfaces. The interfaces may include a phone interface which may be used to access audio information from the recorded multimedia information. The recorded information may be also be accessed via a serial interface using a modem. PRA 100 may also be configured to store the recorded information in a format which is specialized for a particular type of retrieval device or a particular type of software application used for retrieval. For example, if a personal data assistance (PDA) such as a Palm Pilot were used to retrieve the stored information, PRA 100 may be configured to store the information in a storage format specialized for the PDA using reduced-resolution versions of the selected video keyframes.

Fig. 8 depicts various modules for recording information during multimedia presentations according to an embodiment of the present invention. The modules depicted in Fig. 8 include a video splitter module 802, an audio splitter module 804, a video digitizer module 806, an audio digitizer module 812, an external sources information capture module 810, a video keyframe selector module 808, an audio-video synchronizer module 814, an audio-video processor module 816, an interface module 820, and a PRA control module 818. Fig. 8 also depicts storage subsystem 216 (also shown in Fig. 2) which may be used to store information used by or generated by PRA 100. The modules depicted in Fig. 8 may be implemented in hardware or software or combinations thereof. The software modules may be executed by one or more processors in PRA 100.

According to the embodiment shown in Fig. 8, PRA 100 is coupled to MPS 102 via communication links 118 and 116, and to presentation output device 104 via communication links 120 and 122 (similar to the configuration depicted in Fig. 1B). PRA 100 receives video information from MPS 102 via communication link 116 and receives audio information from MPS 102 via communication link 118. Video splitter module 802 makes a copy of (or splits) the video information received from MPS 102 before forwarding the received video information to presentation output device 104 via communication link 120 for output via a video output device. Likewise, audio splitter module 102 makes a copy of (or splits) the audio information received from MPS 102 before forwarding the received audio information to presentation output device 104 via communication link 122 for output via an audio output device. The copied (or split) video and audio streams are forwarded to video digitizer module 806 and audio digitizer module 812 respectively for further processing.

External sources information capture module 810 receives information/signals, for example, audio information, from external sources 106. As previously mentioned, the information from external sources 106 may include for example the audio narration of the presenter, questions or comments from the presentation attendees, and audio signals from other sources. External sources information capture module 810 generally includes one or more listening devices such as microphones which capture audio information from the external sources. The captured audio information is forwarded to audio digitizer module 804 for further processing. According to alternative embodiments of the present invention, external sources information capture module 810 may also include a video camera to capture video information from external sources. The video information captured from external sources 106 is forwarded to video digitizer module 806 for further processing.

Video digitizer module 806 is responsible for converting analog video signals to a digital format. The digitized video information is then forwarded to video keyframe selector module 808 for further processing. Audio digitizer module 812 is responsible for converting analog audio signals to a digital format. The digitized audio information is then forwarded to audio-video synchronizer module 814 for further processing. As previously stated, audio and/or video digitizing may not be required if the audio and video information received from MPS 102 or from external sources 106 is already in digital format.

Video keyframe selector module 808 is responsible for processing the digitized video information to select keyframes from the video information and to discard the other frames. As mentioned above, selection of keyframes rather than all the frames reduces the amount of memory needed for storage of the video information. This in turn reduces the amount of resources needed to store the multimedia presentation information. Various techniques which may be used by the present invention to select keyframes have been described above.

Audio-video synchronizer module 814 is responsible for receiving information related to the video keyframes selected by video keyframe selector module 808 and synchronizing the keyframes with digitized audio information received from audio digitizer 812. As previously mentioned, synchronizing or cross-referencing the selected video frames with the audio information allows a user to retrieve sections of the multimedia presentation and hear the audio associated with the sections.

According to an embodiment of the present invention, the synchronized audio and video information may be stored by audio-video synchronizer module 814 in storage subsystem 216, data storage 114, or some other storage location. The stored information may then be accessed by a user in various formats using different interfaces 820.

According to another embodiment of the present invention, the audio-video information may then be forwarded to audio-video processor 816 for further processing. Audio-video processor 816 may comprise a single processor or a plurality of processors. The processing performed by audio-video processor 816 may include extraction of textual information from the video and audio information, cross-referencing or indexing the extracted textual information with the video/audio information, and other types of processing. Various techniques such as OCR techniques and voice recognition techniques, as described above, may be used to facilitate extraction of textual and other information from the audio and video information. Other known signal processing techniques may also be used by audio-video processor 816 to extract information from the audio and video information.

The multimedia information and the information extracted by audio-video processor 816 may then be stored in a plurality of formats to facilitate subsequent retrieval by a user. As stated above, various different formats may be used for storing the information including SMIL format, HTML+Time format, Flash format, Quicktime format, text format, and other formats which can be used to represent recorded presentations. The recorded multimedia information may be stored in storage subsystem 216, or in data storage device 114 coupled to PRA 100. The information may also be stored on data storage devices (not shown in Fig. 8) coupled to PRA 100 via communication network 112. Audio-video processor 816 may use encoding and compression techniques to minimize the number of resources needed for storing the information.

Interface module 820 enables a user to access the recorded information stored by PRA 100 via a plurality of interfaces. These interfaces may include a telephone interface 820-a, a network interface 820-b, a serial interface 820-c, and other interfaces 820-d. Other interfaces 820-d may include interfaces which allow information to be retrieved via a cellphone, via a PDA, and other like communication techniques.

PRA control module 818 is configured to provide mechanisms for controlling the functionality of PRA 100. For example, PRA control module 818 may

provide controls to instruct PRA 100 to start or stop the recording process. The start/stop controls may be activated using input devices coupled to PRA 100 or other devices such as remote control devices. PRA control module 818 may also include controls for playing back the recorded information using output devices coupled to PRA 100. Other controls typically associated with video and audio equipment may also be included in PRA control module 116. Status information related to PRA 100 may also be displayed or output using PRA control module 818.

The modules depicted in Fig. 8 are merely illustrative of an embodiment of the present invention and do not limit the scope of the invention as recited in the claims.

One of ordinary skill in the art would recognize other variations, modifications, combinations, and alternatives.

Figs. 9A and 9B depict a user interface 900 for retrieving the recorded multimedia information according to an embodiment of the present invention. User interface 900 may be used in conjunction with a web browser and may connect to a web server process executing on PRA 100. For example, user interface 900 may be presented as a web page. User interface 900 may allow a user to access the stored multimedia information, browse the information, search the stored information, randomly access contents of the stored information based on date, time, etc., perform text-based searches, and perform other functions.

As described above, according to an embodiment of the present invention, information related to each individual presentation may be stored in HTML format that is derived from the SMIL format. According to this embodiment, the HTML may include thumbnail images of the keyframes and links to other media types, and computational methods that enable various communication methods. For example, user interface 900 depicted in Fig. 9A displays a presentation in which six keyframes 902-1, 902-2, 902-3, 902-4, 902-5, and 902-6 corresponding to the multimedia presentation are displayed. User interface 900 also includes several features for accessing information corresponding to the presentation. For example, a user may invoke a media player application, such as a Windows Media Player or a RealMedia Player, by clicking or selecting the "Real Media" button/hypertext link 906. The media player invoked upon selecting button 906 may be used to replay the presentation as a video and play the accompanying audio. Selecting "OCR results" 904 button/link allows the user to access results of OCR techniques associated with the presentation. The user may print information related to the presentation by selecting "Print" button/link 908. The user may publish information

related to the presentation by selecting "Publish on the WWW" button/link 914. The user may email the presentation information by selecting "Email button/link 912.

User interface 900 may also include a text search window 910 which allows the user to search the presentation information. Text typed in window 910 is converted to queries that may be matched against, for example, the augmented inverted index described above. Filenames of documents that match the queries and the corresponding HTML representations of the documents may be returned to the user together with an indication of the medium that contained the query text. For example, in response to the user typing the "Summary" in window 910 (as shown in Fig. 9B), a section of keyframe 902-2 containing the word "Summary" may be highlighted as shown in Fig. 9B. Search terms in an audio soundtrack may be expressed by outlining the closest keyframe. Alternatively, user interface 900 may display the transcript of the audio track in which the search terms occur with the search terms highlighted. Users may click on the highlighted terms in the transcript and the video associated with the presentation may be played from that time. Alternatively, according to an embodiment of the present invention, a snippet of the audio track containing the search term may be played. The transcript or audio snippet may be linked to a media player. Various other techniques may also be used to present the results of a search query to the user.

User interface 900 depicted in Figs. 9A and 9B is merely illustrative of an embodiment of the present invention and does not limit the scope of the invention as recited in the claims. One of ordinary skill in the art would recognize other variations, modifications, combinations, and alternatives.

PRESENTATION RECORDER ADAPTER

According to the teachings of the present invention, techniques are disclosed for recording information during multimedia presentations and for facilitating communication of the recorded information to one or more information access devices. A Presentation Recorder ADapter (PRAD) is disclosed which may be configured to receive/record information, including audio information and video information, during multimedia presentations and to communicate the recorded information to information access devices. The information access devices may include devices such as PRA 100, computer systems, hand-held devices, personal digital assistants (PDAs), and other data processing devices. In general, use of the term "information access devices" is intended

to include all possible types of devices which can access information or to which information can be communicated.

Figs. 10A and 10B depict examples of configurations in which a PRAD according to an embodiment of the present invention may be used. The embodiments of the PRAD depicted in Figs. 10A and 10B are merely illustrative of the various configurations in which the present invention may be embodied and do not limit the scope of the invention as recited in the claims. One of ordinary skill in the art would recognize other variations, modifications, combinations, and alternatives.

As depicted in Fig. 10A, a PRAD 1000 may be configured to receive audio information included in the multimedia presentation information from MPS 102 via communication link 1006, and to receive video information included in the multimedia presentation information via communication link 1004. PRAD 1000 may make a copy of or buffer the audio and video information before forwarding the audio and video information to output device 104 via communication links 1010 and 1008, respectively.

PRAD 1000 may also be configured to receive information from external sources 106 during the multimedia presentation. As stated above, external sources 106 may include the presenter, attendees of the presentation, and other sources. Examples of information received from external sources 106 include audio information from attendees of the presentation, audio narration of the person presenting the multimedia presentation, video information, and the like.

According to an embodiment of the present invention, PRAD 1000 may process the information received from MPS 102 and from external sources 106 and store it in a format which facilitates communication of the information to information access devices 1002. The information processed by PRAD 1000 may be stored on PRAD 1000 itself, or may be alternatively be stored on a data storage device accessible to PRAD 1000. The recorded information may be stored in a plurality of formats.

As indicated above, according to an embodiment of the present invention, PRAD 1000 is configured to communicate the recorded information to access devices 1002. The information may be communicated to information access devices 1002 in various modes. For example, according to a first mode, PRAD 1000 may continuously transmit the information to information access devices 1002 via communication links 1012 and 1014 during the multimedia presentation. In this mode, an information access device remotely located from the location of the multimedia presentation may be able to watch and hear the multimedia presentation or portions thereof in real time. In alternative

modes, the information may be buffered by PRAD 1000 and communicated to information access devices 1002 upon receiving requests from the information access devices. A command API may be provided which may be used by information access devices 1002 to receive information buffered by PRAD 1000.

5 Fig. 10B depicts another configuration incorporating PRAD 1000 according to an embodiment of the present invention. In the embodiment depicted in Fig. 10B, output device 104 receives audio and video information included in the multimedia presentation information directly from MPS 102 via communication links 1022 and 1020, respectively. Output device 104 may then process the received information and then
10 forward the processed audio and video information to PRAD 1000 via communication links 1018 and 1016, respectively. PRAD 1000 may also be configured to receive/capture information from external sources 106. PRAD 1000 may process the recorded information and then communicate the information to information access devices 1002 via communication links 1012 and 1014. In the configuration depicted in
15 Fig. 10B, output device 104 may convert the various audio and video formats output by MPS 102 to a suitable standard format which is then forwarded to PRAD 1000. For example, output device 104 may convert a VGA signal format received from MPS 102 to a standard NTSC signal format and then communicate the NTSC signal to PRAD 1000. Since PRAD 1000 receives a standardized format, the design of PRAD 1000 is simplified
20 since it no longer has to support the plurality of formats output by MPS 102.

Communication links 1004, 1006, 1008, 1010, 1012, 1014, 1016, 1018, 1020, and 1022 depicted in Figs. 10A and 10B may be hardwire links, optical links, satellite or other wireless communications links, wave propagation links, or any other mechanisms for communication of information. In a specific embodiment,
25 communication links 1012 and 1014 are wireless communication links. The communication links depicted in Figs. 10A and 10B are merely illustrative of the various configurations in which the present invention may be embodied and do not limit the scope of the invention as recited in the claims. One of ordinary skill in the art would recognize other variations, modifications, combinations, and alternatives. For example, single or
30 multiple communication links may be used to communicate information between the various components shown in Figs. 10A and 10B.

Fig. 11A depicts various modules which may be included in PRAD 1000 according to an embodiment of the present invention. The modules depicted in Fig. 11A include a video splitter module 1102, an audio splitter module 1104, a video digitizer

module 1108, an audio digitizer module 1110, an external sources information capture module 1106, a video keyframe selector module 1112, a URL assignment module 1116, a timestamp module 1114, a PRAD control module 1120, storage subsystem 1118, and transceiver 1122. The modules depicted in Fig. 11A may be implemented in hardware or software or combinations thereof. The software modules may be executed by one or more processors of PRAD 1000.

As shown in Fig. 11A, PRAD 1000 may receive video and audio information included in the multimedia presentation information from MPS 102. Video splitter module 1102 makes a copy of (or splits) the video information received from MPS 102 before forwarding the received video information to presentation output device 104. Likewise, audio splitter module 1104 makes a copy of (or splits) the audio information received from MPS 102 before forwarding the received audio information to presentation output device 104.

The copied (or split) video and audio streams may be forwarded to video digitizer module 1108 and audio digitizer module 1110 and/or to transceiver 1122. When PRAD 1000 operates in a mode during which the recorded information is transmitted to information access devices 1002 in a continuous manner during the multimedia presentation, the copied audio and video information is forwarded to transceiver 1122. Transceiver 1122 may then communicate the information to information access devices 1002. According to an embodiment of the present invention when PRAD 1000 is not operating in the continuous transmission mode, the copied information may be forwarded to video digitizer module 1108 and audio digitizer module 1110 for further processing. In alternative embodiments, the copied information may be forwarded to video digitizer module 1108 and audio digitizer module 1110 even when PRAD 1000 is operating in the continuous transmission mode.

External sources information capture module 1106 receives information/signals, for example, audio information, from external sources 106. As previously mentioned, the information from external sources 106 may include audio narration of the presenter, questions or comments from the presentation attendees, audio signals from other sources, video information, and the like. External sources information capture module 1106 may include one or more listening devices such as microphones which capture audio information from external sources 106. External sources information capture module 1106 may also include a video camera to capture video information from external sources 106.

External sources information capture module 1106 may forward the information captured from external sources 106 to video digitizer module 1108 and audio digitizer module 1110, and/or to transceiver 1122. When PRAD 1000 operates in a continuous transmission mode, the external sources information may be forwarded to transceiver 1122. Transceiver 1122 may then communicate the information to information access devices 1002. The information may be forwarded to video digitizer module 1108 and audio digitizer module 1110 for further processing when PRAD 1000 is not operating in the continuous transmission mode. In alternative embodiments, the information may be forwarded to both the video digitizer module 1108 and audio digitizer module 1110 and also to transceiver 1122.

Video digitizer module 1108 is responsible for converting analog video signals to a digital format. The digitized video information is then forwarded to video keyframe selector module 1112 for further processing. Audio digitizer module 1110 is responsible for converting analog audio signals to a digital format. The digitized audio information may then be forwarded to timestamp module 1114 for further processing. As previously stated, audio/video digitizing may not be required if the audio and video information received from MPS 102 or from external sources 106 is already in digital format.

Video keyframe selector module 1112 is responsible for processing the digitized video information to select keyframes from the video information and to discard the other frames. As mentioned above, selection of keyframes rather than all the frames reduces the amount of memory needed for storage of the video information. This in turn reduces the amount of resources needed to store the multimedia presentation information. Various techniques which may be used by PRAD 1000 to select keyframes have been described above with respect to PRA 100.

After video keyframes have been selected by video keyframe selector 1112, each keyframe may be assigned a unique identifier which may be used to access a particular keyframe. According to an embodiment of the present invention, each keyframe may be stored as a web page and assigned a uniform resource locator (URL). A user using a browser may then access a particular keyframe by providing the URL information for the particular keyframe to the browser. URL assignment module 1116 is responsible for creating web pages for the keyframes and assigning URLs to the web pages.

For example, each web page containing a keyframe may be time stamped. Likewise, audio information may be time stamped. PRAD 1000 may use the time stamps associated with the audio and video information to synchronize the audio and video information.

5 Time stamping allows an information access device to access sections of the multimedia presentation based upon a timeline and hear the audio information associated with the sections. According to an embodiment of the present invention, the time stamped audio and video information may be stored in storage subsystem 1118 or in some other storage location accessible to PRAD 1000. Encoding and compression techniques may be used to
10 minimize the number of resources needed for storing the information.

Transceiver 1122 may be configured to communicate the information received from MPS 102 and from external sources 106 to information access devices 1002. As indicated above, information may be transmitted to information access devices 1002 in various ways. In a first mode, transceiver 1122 may be configured to transmit the information to information access devices 1002 in a continuous manner. The information transmitted in this continuous transmission mode may include the audio and video information received by transceiver 1122 from video splitter 1102, audio splitter 1104, and from external sources information capture module 1106. The transmitted information may also include information stored in storage subsystem 1118. For example, transceiver 1122 may be configured to transfer URLs and audio information associated with the URLs. In alternative embodiments, transceiver 1122 may be configured to transfer only audio information or only video information.

According to another mode, transceiver 1122 may be configured to communicate information to information access devices 1002 based upon requests received from information access devices 1002. In this mode, transceiver 1122 may be configured to receive requests/commands from information access devices 1002 requesting transmission of information stored in storage subsystem 1118. In response, transceiver 1122 may transmit audio and/or video information as requested by the information access device.

30 According to an embodiment of the present invention, PRAD 1000 may support various commands which may be used by information access devices 1002 to request transmission of the audio and video information stored by PRAD 1000 or portions thereof. For example, commands may be provided requesting PRAD 1000 to transmit only audio information, only video, only information received from MPS 102, only

information received from external sources 106, and combinations thereof. For example, an information access device may provide one or more URLs and request transmission of video information corresponding to the URLs. Commands may also be provided requesting PRAD 1000 to transmit information based upon a timeline. For example, an information access device may provide a starting and ending time, and request transmission of information between the starting time and ending time. An information access device may also request transmission of audio and/or video information for the first "N," last "N," etc. seconds of the multimedia presentation. An information access device may also request transmission of video information corresponding to the first "N," last "N," etc. video keyframes. Various other techniques may also be used to access the audio and video information stored by PRAD 1000.

PRAD control module 1120 is configured to provide mechanisms for controlling the functionality of PRAD 1000. The controls may be activated using input devices coupled to PRAD 1000 or other devices such as remote control devices. PRAD control module 1120 may also display status information related to PRAD 1000.

The modules depicted in Fig. 11A are merely illustrative of an embodiment of PRAD 1000 and do not limit the scope of the invention as recited in the claims. One of ordinary skill in the art would recognize other variations, modifications, combinations, and alternatives.

Fig. 11B depicts another simplified embodiment of PRAD 1000. The design of this embodiment is simpler than the embodiment depicted in Fig. 11A as PRAD 1000 does not contain the video keyframe selector 1112 and URL assignment 1116 modules. In the embodiment depicted in Fig. 11B, the digitized video information is communicated to timestamp module 1114. As with the embodiment depicted in Fig. 11A, PRAD 1000 may transmit information to information access devices 1002 in various modes.

Fig. 11C depicts yet another simplified embodiment of PRAD 1000. In the embodiment depicted in 11C, the information recorded by PRAD 1000 is not stored or buffered by PRAD 1000. The information received by PRAD 1000 from MPS 102 and external sources 106 is communicated to transceiver 1122 which transmits the information to information access devices 1002. Accordingly, PRAD 1000 depicted in Fig. 11C transmits information to information access devices 1002 in a continuous manner.

Although specific embodiments of the invention have been described, various modifications, alterations, alternative constructions, and equivalents are also encompassed within the scope of the invention. The described invention is not restricted to operation within certain specific data processing environments, but is free to operate
5 within a plurality of data processing environments. Additionally, although the present invention has been described using a particular series of transactions and steps, it should be apparent to those skilled in the art that the scope of the present invention is not limited to the described series of transactions and steps.

Further, while the present invention has been described using a particular
10 combination of hardware and software, it should be recognized that other combinations of hardware and software are also within the scope of the present invention. The present invention may be implemented only in hardware, or only in software, or using combinations thereof.

The specification and drawings are, accordingly, to be regarded in an
15 illustrative rather than a restrictive sense. It will, however, be evident that additions, subtractions, deletions, and other modifications and changes may be made thereunto without departing from the broader spirit and scope of the invention as set forth in the claims.